Journal of Food Distribution Research
Volume 48, Issue 1

Assessment of Price Volatility in the Fisheries Sector in Uganda

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Abstract

This paper examines price volatility in the African catfish (*Clarias gariepinus*) supply chain in Uganda. The volatility process in the catfish markets was analyzed based on monthly price data from January 2006 to August 2013. A GARCH model is used to estimate the volatility parameters. Empirical results revealed that the value of the first-order autoregressive term and the value of the first-order moving average term were significant for both aquaculture and wild-harvest catfish supply chains. The observed long persistence of volatility in both supply channels suggests a fundamental level of uncertainty and risk in the catfish subsector over the studied period.

Keywords: aquaculture, catfish, GARCH model, price volatility

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Introduction

In sub-Saharan Africa, several price volatility studies have explored output markets for staple foods (Sukati 2013; Minot, 2014; Ngare, Simtowe, and Massingue, 2014), but very little research has been done in the fisheries sector. This paper explores volatility persistence in Ugandan catfish markets. An understanding of the structure of price volatility in Uganda's catfish supply chain is of great interest because catfish has become an important traded species, with exports to regional markets rising even faster than production (Bukenya and Ssebisubi, 2014). There have also been extensive efforts by the government and international donors to increase the country's fish production through investments in aquaculture, and the African catfish has become the predominant cultured species.

However, the consequences of increased catfish production from aquaculture subsector development on price stability in the domestic market have yet to be studied. If monthly fluctuations can be detected and measured, it will be easier to make predictions about prices and to understand their behavior over time. Ideally, well-functioning markets transmit price signals, which allow changes in demand to be met by supply. When demand is greater than supply, producers increase production in response to price signals; this increased production, in turn, helps stabilize prices.

Background

Uganda is a small, landlocked country in East Africa surrounded by Kenya, Tanzania, Rwanda, the Democratic Republic of Congo, and South Sudan. Fisheries resources are among its most significant natural resource endowments. Because about 20% of its surface area is covered with water, Uganda has enormous fisheries resources potential for capture fisheries and aquaculture production (Department of Fisheries Resources, 2012). Capture fishery is basically artisanal and is supported by small-scale fishing communities around the lakes.

The African catfish has recently emerged as the most favored species for aquaculture, accounting for more than 60% of aquaculture production. Farmed catfish is primarily produced by farmers who practice fish farming as one of many other farming activities. With improved market prices, government intervention for increased production, and stagnating supply from capture fisheries, aquaculture has attracted entrepreneur farmers seeking to exploit the business opportunity provided by the prevailing demand. Although the operation of the local marketing system has been the subject of previous studies, the distribution of fish and fish products has improved over the last fifteen years, with increased channels involving middle agents supplying fish to factories involved in industrial fish processing and export and traders supplying fish to rural and urban markets. Pricing is mainly by negotiation, as there are no binding contracts between chain actors and markets are open access. Capture catfish—currently at low volume—is mainly consumed locally, while some farmed catfish finds its way into the regional export market.

Methodology

Data

The time series data used in this analysis consist of monthly farm-raised/aquaculture and wild-harvest catfish prices from January 2006 to August 2013. The data are taken from secondary source data recorded by the Aquaculture Management Consultant (2013). All prices, expressed in Uganda Shillings per kilogram, were deflated using a consumer price index (CPI) deflator to adjust for inflation over the period covered. CPI data were obtained from the Uganda Bureau of Statistics (Uganda Bureau of Statistics, 2013). Table 1 presents the characteristics of the dataset.

Both farm-raised and wild-harvest price series are moderately skewed to the right, indicating that the data have longer right tails than left tails. The kurtosis values are lower than 3, implying that the series distribution produces fewer and less extreme outliers than does the normal distribution. The large value of standard deviation in mean price suggests wide fluctuations in the catfish price series. It is always good practice to plot the time series while searching for potential outliers, trends, structural breaks, and the general characteristics of the data-generating process. Visual inspection of the series (Figure 1) clearly suggests that volatility was present at several points in time. Farm-raised catfish prices are more unstable, particularly between 2008 and 2011.

Table 1. Descriptive Statistics

	Farm-Raised	**Wild-Harvest**
Mean	5,995	3,282
Maximum	8,212	4,818
Minimum	4,153	1,899
Std. Dev.	875	690
Skewness	0.24	0.20
Kurtosis	2.69	2.44
Observations	92	92

Stationarity Tests

The basic assumption in time series econometrics is that the underlying series is stationary in nature. The test for stationarity of the catfish price series under consideration was done using Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) test statistics. The ADF test relies on parametric transformation of the model, while the PP test uses nonparametric statistical methods to take care of the serial correlation in the error-terms. The optimal number of lags was determined using the Schwarz criterion information criteria. The ADF and PP tests were found to be insignificant at the 5% level of significance for both price series (Table 2), confirming the non-stationarity of the level series. However, on differencing the series once, both tests were found to be highly significant at the 1% level, confirming stationarity. Therefore, the need of first differencing of the series was felt for proper modelling of the catfish price series.

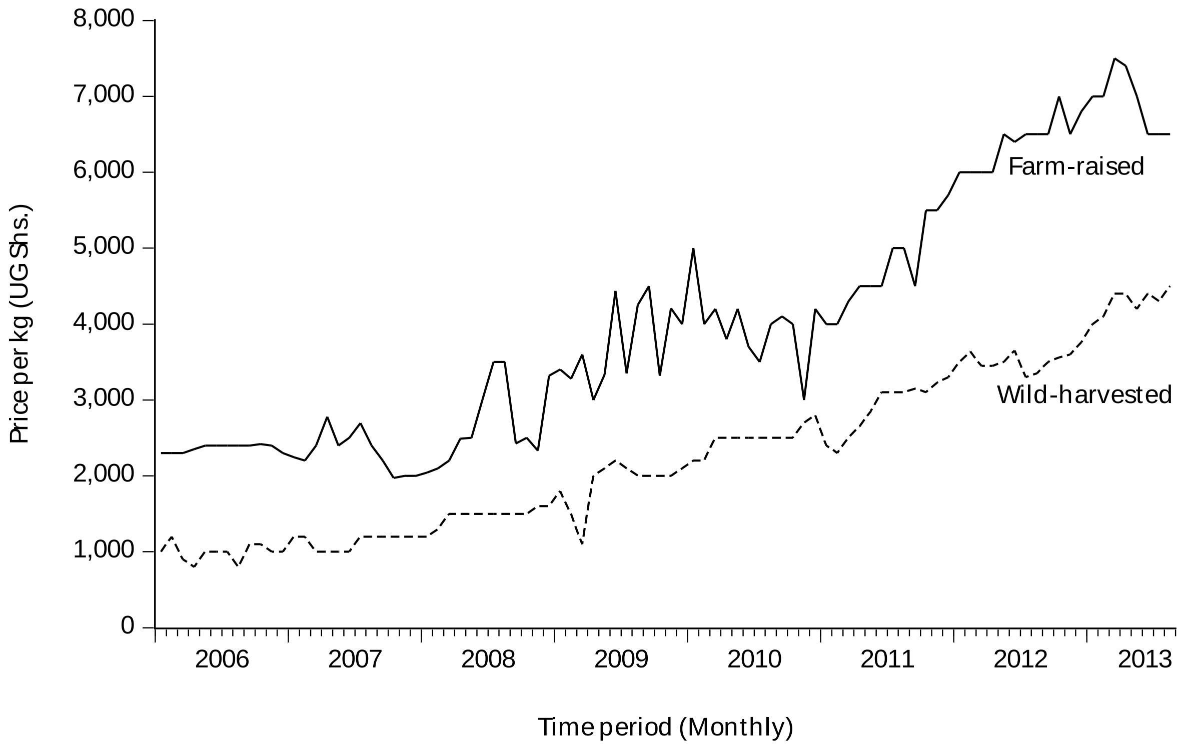

Figure 1. Price Movement in the Catfish Supply Chain.
Source: Aquaculture Management Consultant (2013).

Table 2. Stationarity and LM Test Results.

	Farm-Raised	**Wild-Harvest**
Levels		
ADF	-0.23 [1]	0.24 [0]
PP	-0.118 (17)	1.34 (21)
First Difference		
ADF	-13.67*** [0]	-10.19*** [0]
PP	-19.75*** (18)	-11.81*** (15)
LM Test		
F-stat.	75.88	355.68
Obs*R^2	42.08	73.42
Prob.	0.00	0.00

Notes: [ ] represents lags while ( ) represents bandwidth**,** 0.01 critical values: -2.591**,** Lag Length- based on SIC, maxlag=11.

Price Volatility

Volatility refers to variations in economic variables over a period of time. Large variations in prices that do not reflect market fundamentals become problematic because they can lead to incorrect decisions. The focus in this study was on variations in the catfish price series over time. The series are said to be volatile when a few error terms are larger than the others and are responsible for the unique behavior of the series. This phenomenon is known as heteroscedasticity. The popular and non-linear model for dealing with heteroscedasticity is the autoregressive conditional heteroscedastic model proposed by Engle (1982) and extended by Bollerslev (1986).

Autoregressive Conditional Heteroscedastic (ARCH) Models

The ARCH(q) model for the series $\{\varepsilon_t\}$ is defined by specifying the conditional distribution of ε_t given the information available up to time $t-1$. Letting ψ_{t-1} denote this information, it follows that ψ_{t-1} consists of the knowledge of all available values of the catfish series and anything that can be computed from these values (e.g., innovations, squared observations, etc.). It can be said that the process $\{\varepsilon_t\}$ is ARCH(q) if the conditional distribution of $\{\varepsilon_t\}$ given the available information ψ_{t-1} is

(1.1) $$\varepsilon_t | \psi_{t-1} \sim N(0, h_t)$$

and

(1.2) $$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 ,$$

where $a_0 > 0$, $a_i \geq 0$ for all i and $\sum_{i=1}^{q} a_i < 1$. Equation (1.1) implies that the conditional distribution of $\{\varepsilon_t\}$ given ψ_{t-1} is normal, $N(0, h_t)$. In other words, given the available information ψ_{t-1}, the next observation $\{\varepsilon_t\}$ has a normal distribution with a (conditional) mean of $E[\varepsilon_t / \psi_{t-1}] = 0$, and a (conditional) variance of $\mathrm{var}[\varepsilon_t / \psi_{t-1}] = h_t$. Equation (1.2) specifies the way in which the conditional variance h_t is determined by the available information. Note that h_t is defined in terms of squares of past innovations. This, together with the assumptions that $a_0 > 0$ and $a_i \geq 0$, guarantees that h_t is positive, as it must be since it is a conditional variance.

The GARCH Model

The GARCH model proposed by Bollerslev (1986) is an extension of the ARCH model, in which conditional variance is also a linear function of its own lag. In this study, the GARCH (1,1) model was employed to measure the extent of price volatility in the catfish price series. The model was specified as

(2.1) $$Y_t = X_t \theta + \varepsilon_t$$

(2.2) $$\sigma_t^2 = \omega + \alpha \in_{t-1}^2 + \beta \sigma_{t-1}^2$$

where the mean equation given in equation (2.1) is written as a function of exogenous variables with an error term. Since σ_t^2 is the one-period ahead forecast variance based on past information, it is called the conditional variance. The conditional variance equation specified in equation (2.2) is a function of three terms: a constant term, ω; news about volatility from the previous period, measured as the lag of the squared residual from the mean equation, $\in_{t-1}^2$ (the ARCH term); and last period's forecast variance, σ_{t-1}^2 (the GARCH term), while the error in the squared residuals is given by $v_t = \in_t^2 - \sigma_t^2$. Substituting for the variance in the variance equation and rearranging the terms, the model can be written in terms of the errors as

(2.3) $$\in_t^2 = \omega + (\alpha + \beta) \in_{t-1}^2 + v_t - \beta v_{t-1}.$$

Thus, the squared error follows a heteroscedastic ARMA (1,1) process. The autoregressive root that governs the persistence of volatility shocks in the price series is the sum of α and β. The ARCH parameter corresponds to α and GARCH parameter to β. If the sum of the ARCH and GARCH coefficients is close to 1, this implies that volatility shocks are quite persistent.

Results

The first step in the specification and selection of the model was to test for ARCH effects in the series. This was accomplished using the ARCH – Lagrange multiplier (LM) test on the square of the residuals obtained after fitting the ARIMA model on the two price series. The idea here was to test whether residuals do in fact remain constant. The results test (Table 2) revealed the presence of the ARCH effect for both price series. The implication of these results was that both catfish price series were volatile and needed to be modeled using the Generalized ARCH model (GARCH).

The estimated univariate GARCH (1,1) parameters for the variance equations are reported in Table 3. In this model, the sum ($\alpha_1 + \beta_1$) measures the degree of volatility persistence in the market, which reveals the degree of efficiency in the market. If a market is completely efficient it should immediately correct to any shock. The observed volatility in the monthly catfish price series of wild-harvest supply chain revealed that both the values of the first-order autoregressive term ARCH (α = 0.458) and the value of the first-order moving average term GARCH (β = 0.404) were statistically significant at the 1% level. The observed volatility coefficient ($\alpha + \beta$) was quite persistent of the order of 0.862 (Table 3).

Similarly, both ARCH and GARCH terms (α = 0.212 and β = 0.780, respectively) for the monthly catfish price series of farm-raised supply chain were statistically significant at the 5% and 1% levels, respectively, and the persistent volatility was measured at the order of 0.99. The quite large value of the GARCH term compared to ARCH term in the farm-raised supply chain shows reasonably long persistence of volatility in the price series over the studied period. The results suggest that the wild-harvest catfish price series display a larger degree of efficiency than

Table 3. GARCH (1, 1) Estimates.

Variable	Coefficient	Std. Error	Prob.	Volatility	Half-Life
	Variance Equations			$(\alpha + \beta)$	(Month)
Wild-Harvest					
Constant	0.00149**	0.0006	0.015	0.862	4.7
ARCH	0.45750***	0.1584	0.004		
GARCH	0.40400***	0.1092	0.000		
Farm-raised					
Constant	0.00039	0.0004	0.282	0.992	89.7
ARCH	0.21192**	0.0975	0.030		
GARCH	0.78033***	0.0721	0.000		

Notes: Double and triple asterisks (**, ***) indicate significance at the 5% and 1% levels.

the aquaculture price series. The observed degree of persistence in the respective supply chains was used to estimate the half-life of a volatility shock, $[\log(0.5)/\log(\alpha_1+\beta_1)]$, which measures the time it takes for a shock to fall to half of its initial value. The results (Table 3) show half-life estimates of 4.7 months for the wild-harvest catfish supply chain and 89.7 months for farm-raised supply chain.

Conclusion

Price levels of farm-raised and wild-harvest catfish supply chains in Uganda have increased over the period of study. The large value of standard deviation in mean price suggests wide fluctuations in catfish price levels during 2006–2013. Empirical results of the GARCH model revealed that the value of first-order autoregressive term ARCH and the value of first-order moving average term GARCH were significant for both supply chains. The quite large value of the GARCH term in comparison to the ARCH term in the aquaculture supply chain showed reasonably longer persistence of volatility. Based on these results, a reliable market information system and up-to-date information on supply, demand, and stocks may help in reducing price volatility. Government action is needed to support efforts geared at increasing the capacity of the fisheries sector to undertake systematic monitoring of fish production, improved short-run production forecasts, and market analysis. As noted by previous studies, adequate fish stock is a necessary component of a well-functioning market, particularly to smooth out seasonal fluctuations and time lags in the fish trade (FAO et al., 2011).

Limitation: The data used in this analysis are for a period of almost eight years, a limited set of data to which to apply GARCH models. The findings should therefore be treated cautiously.

Acknowledgements

This research is a component of AquaFish Innovation Lab, supported by USAID (CA/LWA No. EPP–A–00–06–00012–00) and by contributions from participating institutions. The AquaFish succession number is 1463. The opinions expressed herein are those of the author and do not necessarily reflect the views of AquaFish or the U.S. Agency for International Development.

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